culus is seen adherent to the opposite side, and the axis of the style is seen inclining to the ventral tuberosity.

Fig. 4. The same more magnified, showing the cellular somewhat circuitous canal which extends from *a*, the ventral tuberosity, to the cavity of the ovary; the external and internal openings being closed only by a thin layer of cellular tissue: the axis of the short style, together with its termination in the cavity of the carpel external to the funiculus, and also the fibres of the funiculus, are here distinctly seen.

Fig. 5. An ovary of *Ceratophyllum demersum* in longitudinal section.

Fig. 6. A carpel of *Hydropeltis purpurea* in longitudinal section: *a*, the ventral side which is turned towards the axis of the polycarpous ovary.

Fig. 7. A carpel of *Cabomba aquatica*, the dorsum having been removed. Two ovules are seen attached to the lateral fibres, which are continued upwards and meeting at the ventral suture become continuous; at this part the third ovule is seen attached.

Fig. 8. An ovary of *Arum maculatum* in longitudinal section: *a*, the anterior side.

Fig. 9. An ovary of *Sparganium ramosum* in which the dorsal portion of the stigma had become fissured; when dicarpous, which frequently happens, the stigmatic surfaces of the two carpels are turned towards each other.

Fig. 10. *Cryptocoryne ciliata*: *a*, the fissured stigma. (Griffith.)

VI.—*On the Phosphorescence of some Marine Invertebrata.*

By M. A. De Quatrefages*.

I. *Historical review of the Subject.*

1. *Causes of phosphorescence.*—It is well known that the waters of the sea, in some latitudes and under certain circumstances, are phosphorescent, producing a light more or less brilliant. This remarkable phænomenon has always attracted the attention of travellers, and various have been the explanations they have offered. Without going here into useless detail, we will first mention those hypotheses which are now completely set aside, before dwelling on better-founded opinions.

Ancient navigators seem to have indicated a resemblance between the light produced on the surface of the water and that which is due to atmospheric phænomena, by designating the former "meteors of the sea." Something of this idea is evident even in the writings of learned men, who endeavoured to explain this phosphorescence solely by physical or chemical causes. Thus Nollet could see in it only a simple modification of electrical phænomena. Bajon, in his memoirs on the History of Cayenne, regards this light as due to the electricity of the waves, deve-

* From the Annales des Sciences Naturelles, vol. liv. 3rd series, as inserted in Silliman's American Journal of Science for March, 1853.

loped by the force of opposing currents or by the prows of vessels. Other authors have attributed it to phosphoric fires, to the burning of bubbles of hydrogen which rise to the surface to explode, &c. The opinion published by Tingry is of a similar nature. This philosopher regards the phosphorescence of the sea as analogous to that which certain bodies, the diamond in particular, present, after having been awhile exposed to the sun. Without entirely setting aside the agency of animals, he attributes the greater part of the phænomenon to a sort of previous imbibition of the sun's rays, which are thrown out again during the night. He thus explains entirely by physical causes the remarkable intensity of this phosphorescence in tropical seas*.

A more rational if not a more correct explanation, at least for many cases, is that which attributes the phosphorescence of the sea to the decomposition of fishes and other marine animals. This opinion was adopted by Commerson in his manuscripts which are deposited in the library of the Muséum.

A passage very much to the point is quoted by Lesson from one of his manuscripts†: "Phosphorescence is owing to a general cause, that of the decomposition of animal substances, especially of whales and seals, which abound in oily matters." Bory de St. Vincent, Oken, and others have adopted the same view. There is certainly great appearance of probability in this explanation; it is sustained by well-known facts, and sufficiently accounts for certain circumstances of the phænomenon. Still, in many cases it is scarcely better founded than the preceding. The same appears to have been the opinion of Newland, and of those who like him have attributed phosphorescence to the spawn of fishes.

But, since the beginning of the last century, careful observations have been made; and various observers have found that a great number of sea animals have the property of directly emitting this light. Since 1805, Viviani, professor of natural history at Genoa, has discovered in the neighbourhood of that city, and described in a work on the subject, fourteen species of phosphorescent animals‡.

Many travellers have noticed the phosphorescent properties of the Medusæ. Spallanzani, by diffusing in milk the mucus from their bodies, rendered the liquid luminous§. Vianelli attributed

* De la phosphorescence des corps, et particulièrement de celle des eaux de la mer (Journal de Physique, t. xlvii.).

† Dict. des Sc. Nat., article Phosphorescence.

‡ Phosphorescentia maris quatuordecim lucescentium animalculorum novis speciebus illustrata. Genuæ, 1807.

§ Voyage en Sicile.

the phosphorescence of the sea to a *Nereis*; Shaw, to certain flexible zoophytes, &c.

French naturalists have not been behind in this movement. In 1764, Rigaut discovered and described in an unmistakeable manner the *Noctiluca* of Suriray; it is to them that he attributes the phosphorescence of the British Channel and Atlantic Ocean. The Abbé Dicquemare, by researches in the harbour of Havre, confirmed the first results, which, forgotten for a time, were again corroborated by the labours of Suriray at the same locality. The learned hydrographical engineer, M. de Tessan, rediscovered the Noctilucæ, or animals very similar, in the seas of the Cape of Good Hope, at False Bay*. M. Rang mentions their presence on the coast of Algiers†. More recently M. Verhaeghe has been led by his investigations at Ostend‡ to the same conclusions as Dicquemare and Suriray.

The assertion of Rigaut was manifestly exaggerated; the Noctilucæ are not alone in producing this phænomenon. The luminous properties of various Medusæ have been established beyond doubt by the testimony of Peron, Macartney, Tilesius, Banks, Forskal, Humboldt, Ehrenberg, Rathke, &c. Peron and Lesueur, Humboldt, and others after them, have described with enthusiasm the magnificent spectacle presented by shoals of Pyrosomas, which in the dark look like streams of fused metal. Henderson ascribed the light of the Gulf of Guinea principally to the Scyllari and to Salpas§. Certain Acalephs, Mollusca, Crustacea, Annelids, Rotatoria, Lumbrici, Turbellariæ, Echinoderms, Zoophytes and Infusoria have been successively pointed out as capable of phosphorescence; and if we do not here go into more detail on this point, it is because the subject has been so fully treated by Ehrenberg. In the work which the illustrious Secretary of the Berlin Academy has devoted to the phosphorescence of the sea, he has enumerated 450 authors who have treated more or less fully of the production of light by organized beings; and to this memoir we refer those readers who are curious to understand thoroughly the history of the question‖. We annex a table, cited almost entire from M. Van Beneden, in which are

* Comptes Rendus de l'Académie des Sciences, 1840. Rapport fait par M. Arago.

† Cited from Gervais, by M. Van Beneden.

‡ Report of M. Van Beneden on the memoir of Dr. Verhaeghe, entitled "Recherches sur la cause de la phosphorescence de la mer dans les parages d'Ostende" (Bulletin de l'Académie Royale de Belgique, t. xiii. par. 2. p. 3. 1846).

§ Cited by M. Van Beneden.

‖ Das Leuchten des Meeres (Abhandl. der Königl. Akademie der Wiss. zu Berlin, 1834).

enumerated the various species of invertebrate animals whose phosphorescence has been established.

Insects.

Lampyris.—L. noctiluca, L. splendidula, L. italica, L. ignita, L. phosphorea, L. nitidula, L. lucida, L. hemiptera, L. japonica.

Elater.—E. noctilucus, E. ignitus, E. phosphoreus, E. lampadion, E. retrospiciens, E. lucidulus, E. lucernula, E. speculator, E. janus, E. pyrophanus, E. luminosus, E. lucens, E. extinctus, E. cucujus, E. lucifer.

Buprestis.—B. ocellata.

Chiroscelis.—C. bifenestrata.

Scarabæus.—S. phosphoricus.

Pausus.—P. sphærocerus.

Fulgor.—F. laternaria, F. serrata, F. pyrrhorhynchus, F. candelaria.

Pyralis.—P. minor.

Achita.—A. gryllotalpa ?

Myriapoda.

Scolopendra.—S. electrica, S. phosphorea, S. morsitans.

Julus.

Crustacea.

Carcinium.—C. opalinum.

Erythrocephalus.—E. macrophthalmus.

Scyllarus.—Species not determined.

Gammarus.—G. pulex.

Cyclops.—C. brevicornis.

Oniscus.—O. fulgens.

Annelida.

Nereis.—N. mucronata, N. noctiluca, N. phosphorans.

Syllis.—S. fulgurans.

Photocharis.—P. cirrhigera.

Polynoe.—P. fulgurans.

Chætopterus.—C. pergamentaceus.

Lumbricus.—L. phosphoreus.

Planaria.—P. retusa.

Mollusca.

Helix.—H. noctiluca.

Pholas.—P. dactylus.

Pyrosoma.—P. atlanticum, P. giganteum.

Phallusia.—P. intestinalis.

Salpa.—S. zonaria, S. Tilesii.

ECHINODERMATA.

ASTERIAS?
OPHIURA.—O. telactes, O. phosphorea.

ACALEPHA.

PELAGIA.—P. phosphorea, P. noctiluca.
OCEANIA.—O. Blumenbachii, O. pileata, O. hemisphærica (Thaumantias), O. lenticula, O. microscopica, O. scintillans.
BEROE.—B. fulgens, B. rufescens.
CYDIPPE.—C. pileus.
MNEMIA.—M. norvegica.

POLYPI.

PENNATULA.—P. phosphorea, P. grisea, P. rubra, P. argentea.
VERETILLUM?
GORGONIA?
SERTULARIA?
ALCYONIA?

INFUSORIA.

CERATIUM.—C. tripos, C. fusus.
PERIDINIUM.—P. Michaelis, P. acuminatum, P. furca.
PROROCENTRUM.—P. micans.
STENTOR?
SYNCHÆTA.—S. baltica.
NOCTILUCA.—N. miliaris.

We believe that the above list is far from complete, at least as regards marine animals. Our own observations enable us to add at least two species of *Polynoë*, one species of *Syllis*, some species of allied genera, and one or two of *Ophiura**.

* In the above list of phosphorescent Crustacea, *Oniscus fulgens* is a *Sapphirina*; and the *Carcinium* probably belongs to the same genus (see Silliman's Journ. [2] ix. 133). *Regulus*, *Euphausia*, and *Cypridina* are other phosphorescent genera, as observed by the writer; and also *Lucifer* according to Thompson (Zool. Researches, p. 58), and *Thysanopoda*, Edw. *Cypridina* is evidently the genus of the species referred to by Reville as observed to be phosphorescent on a voyage to India (Mém. de l'Acad. des Sci., Savans Etrangers, iii. 267, and Thompson's Zool. Res. p. 41).

Scyllarus must be incorrectly added to the list, as there are no oceanic species of the genus. The error is moreover evident from the fact that the reference of the phosphorescent Crustacea to this genus was made before the species were well understood. Captain Tuckey who states the facts, in his Voyage to the Congo, has the words, "with little Crustaceous animals of the *Scyllarus* genus (attached to them [*Salpæ*])."—evidently inconsistent with the genus *Scyllarus*, which includes large species of very different habits. The term was probably meant for *Squilla*, and the species may have been Schizopods of the family Euphausidæ.—J. D. DANA.

II. *On the mode of producing light by Marine Invertebrata.*

Almost all researches undertaken to discover the manner of producing light in animals, have been made on insects, especially the Lampyri and Elaters. Spallanzani, Burmeister, but above all, Macaire*, have published results apparently decisive. These experiments undertaken and varied by Matteucci†, with all the precautions furnished by experimental science at the present day, leave, we think, no room for doubt. In the insect which he examined, the light was produced by an actual slow combustion analogous to that of phosphorus exposed to the air. This light is extinguished in a vacuum and in the irrespirable gases; it reappears by contact with atmospheric air; it is sensibly brightened in pure oxygen; it continues in animals after they are dead, or even cut to pieces. The particular substance from which it emanates may be isolated, and may leave upon the fingers or the dissecting instrument a luminous streak which disappears only on drying; a little dampness even, in certain cases, is sufficient to restore the phosphorescence; finally, the production of this light is accompanied in the living animal, as well as in its dead carcass, by the escape of carbonic acid. Everything concurs then to show that the phosphorescence of insects, and probably of all aërial animals, is owing to a peculiar secretion, whose substance combining slowly with oxygen produces light.

But can this explanation of phosphorescence be applied to invertebrated animals living in water? Such questions immediately arise, but yet have been overlooked by most naturalists. The greater part of the observers from whose works we have cited have been satisfied with knowing that animals produced the phosphorescence of the sea; some have gone a little farther and have attributed this phænomenon to the secretion of a luminous liquid. This opinion appears generally adopted, and traces of it may be seen even in the writings of some naturalists who have not formally stated it. The experiments of Spallanzani and the observations of many travellers seem fully to confirm this view, which is evidently correct in some cases. Dugès, for instance, has decidedly adopted it, and has implied a resemblance between the phosphorescence of the Medusæ and Annelids, &c., and that of the Elaters and Lampyrides‡.

A very different opinion has been set forth by M. Gilbert, an officer of the corps of naval engineers, who, without being aware of the investigations of others on this subject, had seen the *Noctilucæ*, and describes them rather coarsely, but in a manner easily

* Journal de Physique, t. xciii.

† Leçon sur les phénomènes physiques des corps vivants, 8e leçon.

‡ Traité de Physiologie comparée, t. ii. Montpellier, 1838.

recognised. He explains the production of light in these animals by the development of electricity from the surface of their bodies, a development brought out by the action of the waves*. This explanation is evidently untenable even in a merely physical point of view.

Lesson appears to us one of the first, if not the first, who has seen in phosphorescence a phænomenon distinct from the physico-chemical actions which take place in our laboratories, but without explaining himself very fully on this subject. This naturalist regards phosphorescence as due to Crustacea belonging to different genera; he allows that the seat of this light, emitted on irritation or at the time of procreation, resides in glands placed in a variable number on the sides of the thorax. He adds:—"This light should be regarded as a fact established by investigation, as a modification of the laws of life, and as different from the simple sparkling light resulting from the decomposition of animal substances†."

Carus, losing sight of the philosophy which prevails in his works, adopts the opinion that this phænomenon is a property of *primary animal matter*, which is nothing else than the nervous substance, and which representing the solar element in the animal, necessarily appears luminous to the planetary element‡. He, then, as well as Oken, from whom he cites the passage, "regards the jelly of Zoophytes, Medusæ, &c., as the nervous substance in its lowest stage, from which the other substances embraced within it have not been isolated."

M. Bérard, cited by Dugès§, regards the phosphorescence of animals as due to a kind of luminous imbibition, or purely vital effect, analogous to those which result in different bodies from the action of heat, electricity, light, &c.

Dr. Coldstream published in Todd's 'Encyclopædia' a very interesting article on phosphorescence‖. After having examined the nature of animal light, the natural or artificial circumstances which influence its appearance or intensity, the points of body in different animals from which it is produced, he sums up all that we have learned from different authors of the phosphorescent organs, and the different theories proposed to explain these phænomena. We quote from this English author some passages from this part of his work.

According to Beccaria, Meyen, &c., the phosphorescence of

* Annales maritimes, 1817.

† Dict. des Sc. Natur., 1826, article Phosphorescence.

‡ Traité élémentaire d'Anatomie comparée, traduit par Jourdan, t. i.

§ Traité de Physiologie comparée, t. ii.

‖ The Cyclopædia of Anatomy and Physiology, Part xxii. article Animal Luminousness. 1841.

animals is owing to what they absorb from the rays of the sun, which they throw out again in the dark.

Spallanzani regards phosphorescence as a kind of combustion sustained by the oxygen of the air.

According to Brugnatelli, the light is taken in with the food, and disengaged by particular organs.

Macaire considers the phosphorescent matter as composed of phosphorus and albumen. The variations of intensity apparent in the light arise more or less from the coagulation of the albumen, a coagulation which is increased or diminished at the will of the animal, and permits a more or less rapid combustion.

Tiedemann, Darwin, H. Davy, Heinrich, Treviranus, Burmeister, &c., believe in the secretion of a liquid containing phosphorus, and in the combustion owing to the air introduced by respiration.

Macartney and Todd regard phosphorescence as due to the nervous fluid concentrated and modified by certain organs, so as to appear under the form of light.

The author next proposes his own theory founded on a sort of fusion between the two preceding. With Macartney, he admits that phosphorescence is due to an imponderable agent, and compares it to the production of electricity by certain fishes. But considering the well-known fact of the luminous traces that certain animals leave behind them, he supposes that phosphorus or an analogous substance may very well enter into the composition of the organs which produce the light.

It is plain that Dr. Coldstream, in common with all the authors whom we have cited, believed that phosphorescence should be attributed to but one cause.

This error M. Becquerel* has avoided. After having shown that in the *Lampyris* and other insects phosphorescence is the result of a chemical action at the control of the animal, M. Becquerel relates the observations of Ehrenberg, and admits with him that in certain inferior animals the production of light is owing to a disengagement of electricity. Moreover, he recalls the observations of MM. Quoy and Gaimard, who had seen under the equator, near the island of Rawak, small zoophytes, which while swimming rapidly, drew after them luminous trains. Finally, M. Becquerel, resting on this fact, and on his own observations made in company with M. Breschet, at Venice, in the waters of the Brenta, allows that the phosphorescence of the sea may be owing to an organic substance intimately combined or mingled with the water, analogous to that which covers the herring and other fish when they are phosphorescent.

* Traité de Physique comparée, dans ses rapports avec la Chimie et les Sciences naturelles, t. ii., 1844.

Dr. Coldstream seems not to have known of two memoirs which appeared in Germany, about the same time, and which we have reserved for the close of this history, on account of their peculiar interest.

The first of these works is that of M. Ehrenberg*, and it is incontestably the most complete which has been published on this subject. To all the facts made known by his predecessors, the author adds the result of his own investigations in many seas. At Alexandria he established beyond doubt the fact that the *Spongodium vermiculare*, as also other Algæ regarded as phosphorescent, owe this appearance only to the luminous animalcules adhering to their surface. He describes a new species of *Polynoë* (*P. fulgurans*) found by him in the Baltic, that apparently plays an important part in the phosphorescence of that sea, which also owes its luminous properties to different infusoria. At Christiana and at Heligoland, Ehrenberg observed this phænomenon in many species of Medusæ; at the last locality he met with the *Noctiluca miliaris*, which he calls *Mammaria*. Ehrenberg describes also the very remarkable mode of phosphorescence which appeared in a Nereid, the *Photocharis cirrhigera*. In that Annelid, the light proceeds from two thick and fleshy cirri belonging to the dorsal branch of the feet. The author observed sparks, at first isolated, invade the cirri by degrees, until they became luminous in their whole extent; then the phosphorescence spread through the whole back, until the animal looked like a thread of burning sulphur. The mucus secreted by the *Photocharis* left on the fingers a luminous trace. In the *Polynoë fulgurans*, Ehrenberg regards two large rough bodies, resembling ovaries, as charged with producing the light. In the *Cydippe pileus* and in the *Oceania pileata*, he found that the light starts from the centre, that is, in the neighbourhood of the reproducing organs. In the *Oceania hemisphærica*, a species whose diameter is more than an inch, Ehrenberg saw the sparks from a chaplet around the border; these correspond to the large cirri or to the organs alternating with them.

Ehrenberg sums up in the following manner the important results of his labours:—

1st. The phosphorescence of the sea appears to be owing solely to organized beings.

2nd. A very great number of organic and inorganic bodies shine in the water and out of the water in different ways.

3rd. There is also a light from organized bodies, which is probably owing to vital action.

4th. The active organic light shows itself frequently under the form of a simple flash, repeated from time to time, sponta-

* *Loc. cit.*

neous or provoked. Often also it appears under the form of repeated sparks, following each other in quick succession, under the influence of the will, and very similar to electric sparks. Often, but not always, there is formed by this production of sparks, a mucilaginous humour, gelatinous or aqueous, which is diffused around in great abundance, and is evidently placed in a secondary or passive state of phosphorescence, which continues a long time without requiring any new influence from the organic being, and even lasts after that has been divided or destroyed.

A light which to the naked eye appears uniform and tranquil, shows itself scintillating under the microscope.

5th. The viscous humour which envelopes and penetrates the ovaries seems to be especially susceptible of acquiring this communicated light, which is constantly reinforced by friction, and reappears even when it seems to have ceased.

May not the light emitted by living fishes, by Actinias, and by many other animals covered with mucosity, be sometimes merely communicated?

6th. The relations which exist between the production of light and the sexual functions are evident in the Coleoptera, although the connexion of the small luminous sacs with the reproductive organs may remain concealed. With many marine hermaphrodite animals, phosphorescence appears to be a means of defence and protection, analogous to those of another kind which exist in the *Brachinus crepitans*, the cuttle-fish, the frog, or to the discharges of the torpedo. Whatever it may be, the air and the sea have their phosphorescence.

7th. As yet it is only among the Annelids, and of them only in the *Photocharis*, that a peculiar phosphorescent organ has been discovered; it is external, tufted, frequently giving out light, similar to a thick cirrus, showing a largely cellular structure, and formed within of a mucilaginous substance. The expanded base of the marginal cirri in the Thaumantias (Acalephs) may be regarded as phosphorescent organs, of an unusual kind. The ovaries are more probably luminous, passively and in a secondary manner, although their minuteness and transparency have prevented our ascertaining whether the organs of phosphorescence are placed near them, as for instance in the *Polynoë* and *Pyrosoma*.

8th. The production of light is evidently a vital act very similar to the development of electricity, an act which being completely individual, becomes more feeble and ceases on too frequent repetition, which reappears after a short interval of repose, to the production of which absolute integrity of the organism is not necessary, but which sometimes manifests direct connexions only with the nervous system.

The memoir of Meyen is less extended, but it contains some important facts*. The author admits three kinds of phosphorescence:—1. The phænomenon is owing to a mucosity diffused in water. In that case the water seen in the day has a uniform tint of bluish white. It is often observed in tropical ports, but rarely out on the open sea. This mode of phosphorescence may be produced artificially by washing or by crushing certain Mollusks and Acalephs either in sea-water or in fresh. 2. Phosphorescence results from the presence of certain living animals, endowed with a luminous mucus. This continues even after the death of the animal; it arises from a superficial oxidation of the mucous coating, and it can be reproduced after it seems extinct by passing the finger over the animal. The animals which owe their luminous property to a secretion are, according to the author, Infusoria, Rotifera, Biphoræ, Medusæ, Asterias, Cuttlefish, Sertulariæ, Pennatulæ, Planariæ, Crustacea and Annelids. 3. The third cause of phosphorescence is in some animals from the presence of one or more special organs. Of this number are the *Pyrosoma*, and especially *P. Atlantica*, whose light, of a greenish blue, is very brilliant. Each individual carries behind its mouth a soft opake substance, of a reddish brown colour. This body is slightly conical, and under the microscope thirty or forty red points may be seen; it is this substance which produces the light.

III. *Observations.*

It is apparent from the foregoing statements, that the great majority of naturalists, whatever explanation they have given of the phosphorescent phænomena, have applied that explanation indiscriminately to all cases. Meyen himself, while admitting three kinds of phosphorescence, nowhere expresses the idea that the production of light arises from causes essentially different.

It is in this point, I believe, that the writings of these learned men are deficient. In a note published in 1843†, I endeavoured to establish a different opinion, and to show, that under the general name of phosphorescence, phænomena essentially distinct have been confounded, and which have really nothing in common but the production of light. We have already shown that such is also the opinion of M. Becquerel. After having reviewed all that my predecessors have written on the subject, after having made new experiments and new observations, I am more than ever persuaded that it is really so. Without speaking of the phos-

* Beiträge zur Zoologie, von F. J. F. Meyen, fünfte Abhandlung. Ueber das Leuchten des Meeres (Nov. Act. Nat. Cur. t. xvi. Suppl. 1834).

† Note sur un nouveau mode de Phosphorescence observé chez quelques Annélides et Ophiures (Ann. des Sc. Nat., 2e série, t. xix. p. 183).

phorescence arising from animal decomposition, nor of that which results from mucus in a state of solution, I believe that light is produced in living animals in two ways:—

1st. By the secretion of a peculiar substance exuding either from the entire body or from a special organ. It is probable that in this first mode of phosphorescence the light always arises from a slow combustion. The fact is proved as regards insects; but direct experiments are necessary before the same certainty can exist as to marine Invertebrata, Annelids, Mollusks or Radiata.

2nd. By a vital action, whence results the production of a pure light independent of all material secretion. I had arrived at this result at the time of the publication of my first note. My observations accord entirely with those that Ehrenberg made before me; yet doubts have been thrown out on the legitimacy of conclusions which we had both considered warranted by facts furnished by observation alone. I hope that the experiments which form the subject of the latter part of this memoir will reply to all these objections.

When I published my first note, I was informed of Ehrenberg's results only through a conversation with Humboldt. I have since consulted his memoir, and find that on some points we agree entirely, while we differ on others.

With Ehrenberg I had learned to see in the phosphorescence of the Annelids and Ophiura which I have examined an action essentially vital; but I cannot regard this action as strictly confined either to the organs or the functions of generation, as the learned naturalist of Berlin considers it. I find, it is true, in reviewing my notes, that one of the *Polynoë* which best exhibited the phosphorescence was filled with zoosperms in full maturity, but many other Annelids among those which I have studied were not in that state. Even in admitting that the light may be most brilliant at the period of gestation, I should regard that fact as merely a coincidence arising from the increase of vital energy which is thus very plainly manifested by all these animals. Besides, in the Ophiura, the independence of the light and the generative organs is very evident, since the sparks are seen only along the arms, and the reproductive organs are enclosed in the body, whose walls are very thick.

M. Ehrenberg first made known the fact, that the phosphorescence of Annelids, &c., always results from a combination of microscopic sparks. Here my observations accord entirely with his. We have compared these little flashes to those which are produced from a '*tableau fulminant*' which has been charged from an electrical machine.

But M. Ehrenberg has described in the *Polynoë* a special organ for producing this light. Here we differ. In the *Polynoë*, as

in the Syllæ and the other little Nereids which have been the subject of my investigations, I have never perceived any peculiar organ from which the light appeared to emanate. The muscles alone, and particularly the muscles of the feet, have appeared to me to present this phænomenon. I have seen, moreover, some Syllæ for instance shine through the whole extent of their bodies; and in this case the comparison to a thread of burning sulphur is striking and just. This is the appearance to the naked eye; but under the magnifying glass this thread is divided into a double range of luminous points corresponding to the feet.

I am far from denying that certain animals may have organs charged with secreting light, as certain fishes possess those for secreting electricity; but up to this time I have never seen that sparkling light show itself except in the muscles and at the moment of contraction. There may undoubtedly exist on this point reasonable uncertainty with regard to those Annelids whose foot-muscles are lodged in the abdomen; but this cannot be true with respect to the *Ophiura,* and nothing is easier than to prove this even to the unaided vision, as in the latter the phosphorescence appears along the arm, and only during movement. Moreover, the details which will be given beyond of the phosphorescence of the *Noctilucæ* will show plainly, I believe, that these animals have no special organ for producing the light.

Finally, the *Photocharis* observed by Ehrenberg secreted a liquid which left luminous traces on the objects which came in contact with it. This peculiarity I have also met with in one of my Annelids; but generally in the latter, and especially also in the *Ophiura,* the light was owing entirely to the scintillations, and disappeared with them. It is, however, easy to believe that the modes of phosphorescence which we have admitted may coexist in the same animal.

[To be continued.]

VII.—*On the Structure of the Leaves of Palms.*

By M. A. Trécul*.

Notwithstanding the important investigations of Von Mohl and Mirbel, there still remains considerable uncertainty upon the structure of the leaf in the Palms. For instance, what is the ligula of the flabelliform leaves of many of these plants? Are their lobes the natural divisions of the leaf, or only accidental rents of its substances? Both these opinions are advanced. How is the plaited limb of these leaves formed? Are the pin-

* From the Comptes Rendus, May 16, 1853, p. 857.